DOCUMENT RESUME

ED 249 688 EC 170 487

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TITLE The Effectiveness of the Instructional Use of Computers for Students with Mild Learning Problems: A Review of the Literature and Research.
PUB DATE 83
NOTE 24p.; Concepts and Issues Paper, University of Illinois at Urbana-Champaign.
PUB TYPE Information Analyses (070)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Computer Assisted Instruction; Computer Managed Instruction; Computer Software; Educational Technology; Elementary Secondary Education; *Microcomputers; *Mild Disabilities

ABSTRACT

The effectiveness of the instructional use of computers as measured by student achievement is examined. Attention is given to the following issues: (1) attributes that may make computer instruction applicable to students with mild learning problems; (2) problems and limitations of computer instruction; and (3) future potential and needs of computer instruction. Computer-assisted instruction (CAI) was found to be more effective as a supplement to, rather than a replacement of, traditional instruction. In general, instructional use of computers was found to be effective for special needs students. The need for future research in the following areas is cited: (1) computer managed instruction, (2) microcomputer program characteristics and their effects on rate and retention of learning, and (3) the relationship between computer program characteristics and learner characteristics. (JW)

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THE EFFECTIVENESS OF THE INSTRUCTIONAL USE OF COMPUTERS FOR STUDENTS WITH MILD LEARNING PROBLEMS: A REVIEW OF THE LITERATURE AND RESEARCH

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CONCEPTS AND ISSUES PAPER

Submitted in partial fulfillment of the requirements
for Special Education 492
University of Illinois at Urbana-Champaign, 1983

Urbana, Illinois

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Running head: COMPUTER EFFECTIVENESS

Abstract

The effectiveness of instructional use of computers as measured by student achievement is explored for its possible application to students with mild learning problems. Attention is given to attributes that may make computer instruction applicable to special students, problems and limitations of computer instruction, and the future potential and needs of computer instruction. Computer-assisted instruction (CAI) used to supplement traditional instruction (TI) was found to be more effective than CAI used to replace TI. More exploration needs to be done regarding the use of computer-managed instruction.

The increasing number of computers in the United States and the rapid integration of computers into American society has led to an increased interest in the educational use of computers. Watson (1979) reported that from the development of the first computer in the 1940s, the number of computers has increased from 12 in the entire United States in 1950 to more than 50,000 by 1979. Today's computers are 1000 times faster, more reliable, and more cost effective than those built in the 1950s. Although 85% of secondary schools now use computers for some purpose, only 42% of elementary schools have microcomputers available (Becker, 1983). Two of the first research efforts related to educational uses of computers were the University of Illinois' PLATO project(1960) and Stanford University's Mathematical Studies project (IMSSS-1963).

Educators and researchers have presented differing views about instructional uses of computers. A. V. Vandemeer predicted in 1960 that CAI would be equal to or superior to conventional methods of instruction in all areas (Dence, 1980). In 1966 Patrick Suppes, one of the early researchers and developers of computer courseware at Stanford University, stated:

> The truly revolutionary function of computers in education, however, lies in the novel area of computer-assisted instruction....One can predict that in a few more years millions of school children will

have access to ... the personal services of a tutor as well-informed and responsive as Aristotle.(p. 207)

In recent years, educators seem to be approaching the educational use of computers with more caution, and many question the effectiveness of the use of computers in student instruction. Schiffman, Tobin, and Cassidy-Bronson (1982) caution that despite the enthusiasm being shown for the computer, "there is little or no evidence to indicate that computer-assisted instruction in the school is more efficient or effective than traditional instructional strategies"(p. 422). According to Dence (1980), "A review of studies using CAI under different conditions and comparing it to traditional methods of instruction reveals an abundance of no-significant differences between the two methods"(p. 51).

Several authors (e.g., Stallard, 1982; Hofmeister, 1982; Schiffman et al., 1982; and Walker, 1983) have reconstructed the many "fads" in recent years which were hailed as <u>the</u> answer to all educational problems--instructional television, teaching machines, programmed instruction, the "Talking Typewriter", etc.--but each of these fell short of their potential. Yet after their words of caution, each of these authors recognized the great potential of CAI. Schiffman et al. (1982) stated, "However, despite the controversy of computer effectiveness in general instructional programs, there is great support, enthusiasm,

and anticipation in the field of special education"(p. 422). Because none of these educators supported their conclusions with research about the effectiveness of the educational use of computers, this paper will address the following questions:

(1) How effective is the instructional use of computers for students with mild learning problems?

(2) What attributes does computer instruction have which may make it useful for special students?

(3) What are the problems that may limit the effectiveness of using computers for instruction?

(4) What are the potential and needs for future instructional use of computers?

Research on Effectiveness of IUC

Areas of Research Included

This review includes only studies in which the effectiveness of the computer instruction as compared to traditional instruction was measured by student achievement. Only those studies were included in which the research population was at or below the middle school level and/or was part of a group with special needs. Because many of the early elementary studies dealt with the basic skills and often included disadvantaged populations, it is felt that many of the findings can be generalized to students with mild learning problems.

For the purpose of this review, instructional uses of the computer(IUC) have been divided into computer-assisted

instruction (CAI) and computer-managed instruction (CMI). CAI has been defined as direct use of the computer by students for instruction (Burke, 1982). The modes or types of CAI are most commonly referred to as tutorial, drill and practice, problem solving, gaming, simulation, inquiry, and dialogue (Dence, 1980). In some cases CAI was used as a supplement (C-SUP) to traditional instruction (TI), while in a few cases it replaced (C-REP) other instruction for that subject area.

CMI has been referred to by Dennis (1979) as using the computer to control and expedite the "traffic" involved in instruction. Some CMI functions are diagnosing, assigning, routing through the curriculum, communication, controlling and using resources, progress evaluation, and record keeping. Leiblum (1982) sees the central theme of CMI as using computer technology to manage and produce more effective instruction by handling student testing of progress and referring students to outside instructional materials.

Effectiveness Studies

Two major reviews appeared in the early 1970s that summarized the results of many research studies regarding the instructional use of computers. In 1972 Vinsonhaler and Bass summarized nine studies that meet the criteria of this review and are identified in Table 1. They found strong evidence for the effectiveness of C-SUP over traditional instruction alone when effectiveness was measured by

standardized achievement tests. All studies involved CAI in the form of drill and practice in mathematics and language arts. Average gain scores were determined by finding the difference between pretest and posttest scores in grade-year equivalents (GE). The difference between the average gain scores of the CAI groups and control groups resulted in the GE months listed in Table 1.

Five comparisons were made in language arts in which the computer groups achieved gain scores ranging from .1 to .4 (1-4 months) higher than the control groups. In arithmetic 29 comparisons were made; 26 of these resulted in CAI group gains ranging from .03 to .88 GE higher than those of the control group gains. One comparison resulted in no difference while two comparisons resulted in control group gains higher than the CAI group gains.

Insert Table 1 about here

Edwards, Norton, Taylor, Weiss, and Dusseldorp (1975) reviewed studies comparing C-SUP and C-REP to other types of instruction as well as making a variety of other comparisons. The studies that meet the criteria of this review and not already reviewed by Vinsonhaler and Bass are listed in Table 2. Five of the studies reviewed by Vinsonhaler and Bass were also included in the Edwards, et al. review, and have been identified in Table 1. When CAI was used as a supplement to traditional instruction, all

studies resulted in greater gains for the computer groups than for the control groups having only traditional instruction. However, when CAI was used to replace other instruction, the results were inconsistent. In 3 studies the computer groups had greater gains; in 3 studies the average gain was equal to that of the control group; and 2 studies showed mixed results. This seems to indicate the greater effectiveness of CAI when it is used to supplement TI than when it is used to replace TI. These findings were consistent with the C-SUP studies reviewed by Vinsonhaler and Bass.

Insert Table 2 about here

Other studies related to the effectiveness of instructional uses of computers for groups with special needs are summarized in Table 3. IUC was found to be generally effective in a wide variety of situations and with diverse student populations.

Berthold and Sachs (1974) used a repeated measures design with six special education students ranging in age from 9 to 11. Each student received tutorial instruction for a period of six weeks. During randomly assigned two-week blocks, instruction was presented by a teacher alone, a computer alone, or a combination of teacher and computer. Instruction by the teacher and combined instruction yielded significantly greater performance

improvement than computer instruction alone. Although combined instruction gave a somewhat higher performance improvement than teacher instruction, it was not significantly higher.

Haberman (1977) matched 18 socially/emotionally disturbed subjects, then randomly assigned them to either the experimental or control group. The experimental group worked exclusively on the computer for arithmetic instruction while the control group was instructed in the usual manner. After two months, the experimental group had significantly higher grade gain scores than the control group as well as significantly higher total time on task and independent time on task.

Chiang et al. (1978) described ASSIST, a demonstration project involving teacher-controlled programs, which were developed by teachers using an authoring system. The study involved about 200 elementary and junior high students with mild learning problems. Matched control and experimental groups were pre- and post-tested. Ten minutes of computer instruction daily was suggested for the experimental group, but it varied greatly. On the average each student took 5.3 lessons and 33 minutes of instruction per week. Only 164 students received both the pretest and posttest. Gains were positive in 75% of the cases in the treatment group, and nearly half were significant after being adjusted for differences between the treatment and control groups. The gains seemed to be associated with the subjects in which the

teachers emphasized the use of computers--for some schools it was in reading, for others it was in math.

Insert Table 3 about here

Lally (1981) used CAI instruction to supplement other instruction in building sight word vocabulary for a group of eight mildly mentally retarded nonreaders, aged 9 to 16. After four weeks of instruction, the experimental group had an average increase in sight vocabulary of 128% compared to the control group's increase of 34%. The increase was retained over a period of 23 weeks including summer vacation.

Lutz and Taylor (1981) designed a study unusual in that it involved a developmental program for high-risk pre-schoolers based on comparing a computer-managed behavioral curriculum and child tracking system to more traditional forms of services. No significant differences were found on the Peabody Picture Vocabulary Test or the Memphis Comprehensive Developmental Scale, but the treatment group was significantly higher on the gain on the Boehm Test of Basic Concepts. The treatment group was significantly lower in cost per child and was significantly higher in maternal interaction as measured by the Maternal Teaching Style Research Instrument. Lutz and Taylor hypothesized that the advantages of the computer-managed program resulted from the more specific planning and the immediacy of feedback.

Two groups of emotionally handicapped students were rotated in a study by Carman & Kosberg (1982) so that each group was the experimental group part of the time and the control group part of the time. All 40 students were between two and four years behind grade level in reading and mathematics. During the year of study a PLATO CMI program was used for math instruction. Analysis of math achievement test scores showed significantly higher gains for the experimental group during the first two periods, but no difference in the last period. The average mathematics grade increase for the total group was 3.3 GE with a median increase of 1.26 GE. These increases compared to a prior learning rate for the group of .66 GE per year.

Dorsey and Burleson (1982) reported a microcomputer pilot project begun to assist the slow learner with math, but expanded to involve all 550 K-6 elementary students, 56% of whom had Spanish surnames. Computer instruction time was only about 15 minutes per week, yet achievement gains at the end of the year were found to be higher when they were compared to the gains for the same students the previous year--1.7 GE higher in math and 1.1 GE in reading for the second grade, and 2.1 GE in math and 1.7 GE in reading for the third grade.

IUC Attributes Applicable to Special Education

Many educators have named attributes of IUC that make it especially useful for special education. Stallard (1982) mentioned its motivational quality, its use for

individualizing instruction, its adaptability to student needs, its efficiency for management and diagnosis, and its cost effectiveness. Because special education traditionally has a higher cost per pupil than regular education, IUC is more likely to be cost effective in special education. Hofmeister (1982) included the use of the computer for word processing as an advantage for improving written expression and as a mode for achieving computer literacy for special education students. Hannaford and Taber (1982) referred to the microcomputer's ability to interact with the learner and to present immediate appropriate feedback and reinforcement as characteristics useful for special education students.

Bishop (1983) stressed that computers can help the teacher to determine students' strengths and weaknesses, to determine whether skills are mastered or not, and therefore to enhance the quality of the students' instructional time. Vitello and Bruce (1977) listed three attributes of CAI which make it useful for handicapped students: (a) the multi-sensory presentation of material, (b) the repetition of material, and (c) the immediate remediation of incorrect responses.

Cogen (1969) included the following in a comprehensive list of advantages for computer use with the mentally handicapped: (a) learner control, (b) student participation, (c) branching to review or enrich, (d) attention-getting, (e) short and frequently changing lessons, (f) instant knowledge of results, and (g) structured programs.

Problems & Limitations

Budoff and Hutton (1982) sum up three of the major problems of IUC--software(computer programs), hardware(computer equipment), and teacher computer literacy--by stating:

> This time the microprocessor may have the potential to fulfill its promise.... However, many of the old pitfalls remain.... The promise must not be oversold before the hardware and software are available to fulfill the expectations.... Actually the field is just starting to develop, and the school user must be wary and knowledgeable about the opportunities, which are potential, not currently existing. When ... teachers become computer-literate, they will be more knowledgeable about how to manage the use of the computer with individual students.(pp. 123-4)

Hannaford and Taber (1982) also mentioned software as a major limitation because of the differences between author languages for different brands of microcomputers and because of the fact that educational aspects of software often take second place in importance to the technological aspects. Mason (1980) included cost and the difficulty of reading the monitors among the problems of IUC.

Hofmeister (1982) named these problem areas: (a) the heavy visual emphasis of most software that may be inappropriate for some problem learners, (b) instructional fragmentation, (c) individualization of computer instruction

may decrease social interaction, and (d) computer access. Walker (1983) emphasized the lack of standardization of computer products, the scarcity of good programs, and the inability of computer instruction to take the place of conventional instruction.

Future Potential & Needs of IUC

Burke (1982) predicted cheaper and smaller hardware, increased reliability, storage, and portability, and the use of nation-wide data bases to bring information within reach of any classroom. He suggested that software will soon be easier to modify and will run on a wider variety of microcomputers. Authoring systems, which are software packages that guide the CAI author through the programming process without needing to know a programming language, may help to overcome the problems of software shortage and adaptability. Authoring languages may become more standardized and easier to use.

Hallworth and Brebner (1980) predicted the increasing use of multi-media terminals for CAI in the future with image projection, audio output, and voice recognition. Braden (1982) stated there will be future adaptations and uses of television and interactive computers for instructional use.

Because of reported negative attitudes of many teachers in surveys, Stallard (1982) and Ragghianti and Miller (1982) recognized the need for increased computer literacy for teachers. Stallard also emphasized the need for educators

to become involved in the technological developments for educational use. Schiffman, et al. (1982) recommended an interdisciplinary approach between educators and technologists if computer use is to become an effective aid for the education of the handicapped.

Suppes (1966) suggested problems which must be solved in the future in order to make best use of computers; the computer needs to be able to (a) respond to complex questions and answers and carry on a dialogue in natural language, (b) recognize a child's spoken words, and (c) use student's records and previous learning pattern to determine amounts and direction of future instruction. Suppes recommended research into fundamental theories about learning and retention by students, the effect of particular types of reinforcement and responses, and different cognitive styles. Jurgemeyer (1982) suggested there are concepts involved in programmed instruction design which should be examined for its applicability to computer instruction as a way of "avoiding reinvention of the wheel."

Conclusions

Most studies have shown that the instructional use of computers is effective as a supplement to traditional instruction, but is not so effective as a replacement for traditional instruction. The studies of C-REP did not indicate whether the teacher time saved was or could have been put to more valuable instructional use; this is an aspect which might be included in future research. Very

little research was found involving CMI but it was generally found to be effective. In general IUC was found to be effective for students with special needs. IUC attributes which could enhance instruction of special students mainly deal with its immediacy and adaptability to the individual. Lack of standardization of computer hardware and software, lack of good, pedagogically sound software, and need for teacher computer literacy were identified as the major problems for IUC that need to be solved. The future is likely to bring the solution to these problems as well as the introduction of many technological advances in multi-media use of computers for instructional purposes.

Even though a fairly large body of research was found dealing with the effectiveness of IUC, very little of it involved the microcomputer. Since microcomputers are becoming more common and have somewhat different capabilities than time-sharing computers, future research needs to be done using the microcomputer. Research is needed to determine specific program characteristics which affect rate and retention of learning--types of feedback, methods of remediation, timing of feedback, length of lessons, structure of lessons, use of graphics, use of sound, and amount and arrangement of repetition. Studies should also be done to determine possible relationships between program characteristics and specific learner characteristics. With the limited access to computers in the classroom likely to continue for a number of years, more

exploration should be done in the area of computer-managed instruction. Computer use for instruction has great potential for special education, but it will probably be a number of years before there is widespread use in the classroom.

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TABLE 1

Vinsonhaler & Bass(1972) Summary of Studies of CAI Used as a Supplement Compared to Traditional Instruction

STUDY	SUBJECT SAMPLE	AREA & DURATION	CAI GAIN ABOVE CONTROL IN MONTHS
Fletcher & Atkinson(1971)*	Grade 1 88 students	Lang. Arts 10 months	Grade 1 = 4
Wilson & Fitzgibbons(1970)	Grade 4 68 students	Lang. Arts 4 months	Grade 4 = 4
Harcourt Brace(1971)	Grades 4-6 1800 students	Lang. Arts 5 months	Grade 4 = 3, Grade 5 = 1 Grade 6 = 3
Suppes & Morningstar (1969)	Grades 4-6 182 students	Arithmetic 9 months	Grade 4 = 7, Grade 5 = 12 Grade 6 = 5
Suppes & Morningstar (1969)*	Grades 1-6 665 students	Arithmetic 7 months	Grade 1 = .3, Grade 2 = 4.1 Grade 3 = 5.4, [Grade 4 = -.4] Grade 5 = 5.4, Grade 6 = 1
Suppes & Morningstar(1969)*	Grades 1-6 Low ability, 515 students	Arithmetic 3 - 5 months	Grade 1 = 8.8, Grade 2 = 5.8 Grade 3 = 7.7, Grade 4 = 4.1 Grade 5 = 4, Grade 6 = 5.9
Weiner et al.(1969)	Grades 2-6 3000 students	Arithmetic 5 months	Grade 2 = 4.2, Grade 3 = 3.7 Grade 4 = 1.9, Grade 5 = 6.4 Grade 6 = 2.7
Scrivens(1970)*	Grades 3-6 391 students	Arithmetic 9 months	Grade 3 = 3, Grade 4 = 4 [Grade 5 = - 4, Grade 6 = 0]
Arnold(1970)*	Grades 2-6 335 students	Arithmetic 9 months	Grade 2 = 3, Grade 3 = 5 Grade 4 = 4, Grade 5 = 5 Grade 6 = 5

*Note. Study also included in review by Edwards, et al.(1975)

TABLE 2

Research Related to the Effectiveness of CAI Compared to Traditional Instruction by Edwards et al.(1975)

STUDY	SUBJECT SAMPLE	INSTRUCTION	RESULTS*
Crawford (1970)	Grade 7	C-SUP in arithmetic	+
Martin (1973)	Grades 3-4 Low ability	C-SUP in arithmetic	+
Abramson & Weiner(1971)	Grades 2-6	C-REP in arithmetic	+=
Street(1972)	Grades 3-7	C-REP in arithmetic	=
Johnson(1966)	Grades 7-9	C-REP in math	=
Wilson & Fitzgibbon(1970)	Grades 4-5	C-REP in English	+
Atkinson(1968)	Grade 1	C-REP in reading	+
Diamond(1969)	Grades 7-10	C-REP in reading	=
Diamond(1969)	Grades 7-10	C-REP in biology	+
Wing et al.(1967)	Grade 6	C-REP in economics	+-, less retention

*Note. Meaning of symbols for study results.
+ means the CAI group gain was greater than the TI group.
= means no difference between CAI and TI groups.
- means CAI group gain was less than TI group.
Mixed symbols mean different results in various areas of the study.

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TABLE 3

Additional Research Related to the Effectiveness of Instructional Uses of Computers with Special Populations

STUDY	SUBJECT SAMPLE	INSTRUCTION	RESULTS
Berthold & Sachs(1974)	6 Brain-dam. Age 7-11	Compared teacher only, computer only, & combined one-to-one tutorials	% of performance improvement, combined=30.26%, tchr only= 27.06% computer only= 2.96%
Haberman(1977)	18 soc/emot. disturbed	CAI compared to TI in arithmetic	CAI gains greater
Chiang, et al. (1978)	164 EMH, EH, LD,Lang. Handi.	C-SUP vs. TI teacher-controlled 1 year, 30 min/wk.	CAI gains greater than control for 75% of cases
Lally(1981)	Age 9-16 Non-readers	C-SUP compared to TI reading sight words	CAI group gains greater good long-term retention
Lutz & Taylor(1981)	pre-school high-risk	CMI compared to TI in developmental program	CMI group equal or better lower in cost
Carman & Kosberg(1982)	Age 7-14 Emot. handi.	CMI/C-SUP compared to TI in math Oct-June	CAI avg. math gains = 3.3 GE median = 1.26 GE
Dorsey & Burleson(1982)	550 K-6 Grade 56% Spanish	C-SUP vs. TI 1 yr, 15 min/wk.	CAI gains ranged 1.1-2.1 GE higher